The agreement shown between the level not only of Lake Victoria but also of Lake Albert, and sun spots is so remarkably good that some intimate connection between the two variables must certainly be accepted, and this is the primary contention of the geophysical memoir referred to. By making use of the scattered reports of explorers previous to the installation of lake gages the lake-level curve can be carried back another eight years, and still it agrees with the sun-spot curve. Data for 1923 also support the agreement. Assuming a correlation of 0.8 for the 36 years 1888–1923 (between level of Lake Victoria and sun-spot numbers) the probable error works out as only $\pm.04$, and the coefficient is 20 times the probable error, which amounts almost to absolute certainty. To reduce the number of "occasions" to the six or seven maxima and minima amounts to assuming beforehand the truth of what you wish to disprove.

Working out the partial coefficients roughly we obtain lake level, sunspots, rainfall constant, $r=+0.92$; lake level, rainfall, sunspots constant, $r=+0.80$.

The first figure, 0.92 is practically the same as the crude coefficient between lake level and rainfall. This means that the level of the lake is determined almost entirely by two factors—rainfall, and sunspots—independently of their effect on rainfall. It is difficult to see any other means than evaporation through which the latter effect can operate. The run-off from the lake is so small (only about 6 per cent of the rainfall) that its variations can not appreciably affect these relationships.

The conclusion drawn from the data is therefore solely that the level of the lake is determined almost entirely by the balance between rainfall and evaporation. At first the chief effect was attributed to the latter, but Mr. Phillip's rainfall figures show rainfall to be of equal importance. Variations due to run-off, seepage, etc., are necessarily relatively unimportant, but they were so far from being ignored that on page 342 of the Memoir an attempt is made to calculate them. I therefore can not understand why I am accused of having "set aside one of the fundamental laws of hydrology * * *." Actually this elementary law was present in my mind throughout.

The use of temperatures at Entebbe for calculating evaporation would be irrelevant for two reasons. In the first place at stations on the edge of large bodies of water the sun-spot cycle of temperature variations is greatly modified by the incidence of lake or sea breezes, so that they are not a fair indication of the temperature of the mass of air blowing over the lake or sea, and, in the second place, with higher land temperatures some distance inland the wind movement would be greater and this would increase the evaporation disproportionately to the rise of temperature.

THE FREQUENCY OF WINDS OF DIFFERENT SPEEDS AT FLYING LEVELS BETWEEN NEW YORK AND CHICAGO: A FURTHER ANALYSIS OF THE RECORDS OF THE AIR MAIL SERVICE[1]

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[Weather Bureau, April 4, 1924]

The effect of winds of different speeds on the performance of aircraft in regular service over a given route was examined in some detail by the authors in an earlier paper.[2] Because of the importance of this factor of wind frequency in aircraft operations it has been considered desirable to extend the analysis of the previous paper, particularly as regards the New York-Chicago route, in order to confirm or modify the earlier conclusions. The records of the air mail for the fiscal year 1923 have therefore been examined and combined with those for the fiscal year 1922, as previously determined, and the results of this more complete analysis are considered in the paragraphs which follow.

The flight data upon which the analysis is based were taken directly from the operating records of the air mail and cover the two-year period from June, 1921, to May, 1923, inclusive. Table 1 presents the number of flights by month and by season, the average speed maintained and the percentage of flights completed to the total number possible. This table corresponds to Tables 1 and 2 of the earlier report, to which reference should be made for a description of the route and of the general method of computation.

Table 2 presents the data corresponding to those of Tables 9 and 11 of the former report. Of particular interest is the last line which gives the wind factor as determined for the two consecutive years.

[1] Presented before American Meteorological Society at Washington, D. C., Apr. 30, 1924.

[2] The Wind Factor in Flight: An Analysis of one Year's Records of the Air Mail. Mo. WEATHER REV., March, 1923, 51: 111–125.

TABLE 1.—*Flights made between New York and Cleveland and between Cleveland and Chicago, June, 1921, to May, 1923, inclusive*

	January	February	March	April	May	June	July	August	September	October	November	December	Spring	Summer	Autumn	Winter	Annual
	Number of days available, excluding Sundays and holidays																
	51	46	54	50	52	52	50	54	50	52	50	51	156	156	152	148	612
	Number																
New York-Cleveland	42	36	43	46	49	51	50	52	49	49	39	44	138	153	137	122	550
Cleveland-Chicago	46	39	50	48	51	52	50	54	50	52	45	46	149	156	147	131	583
Chicago-Cleveland	47	40	51	48	51	52	50	54	49	52	42	45	150	156	143	132	581
Cleveland-New York	40	38	44	45	49	51	50	52	49	50	39	47	138	153	138	125	554
	Percentage of possible																
New York-Cleveland	82.3	78.3	79.6	92.0	94.2	98.1	100.0	96.3	98.0	94.2	78.0	86.3	88.5	98.1	90.1	82.4	89.9
Cleveland-Chicago	90.2	84.8	92.6	96.0	98.1	100.0	100.0	100.0	100.0	100.0	90.0	90.2	95.5	100.0	96.7	88.5	95.3
Chicago-Cleveland	92.2	87.0	94.4	96.0	98.1	100.0	100.0	100.0	98.0	100.0	84.0	88.2	96.2	100.0	94.1	89.2	94.9
Cleveland-New York	78.4	82.6	81.5	90.0	94.2	98.1	100.0	96.3	98.0	96.2	78.0	92.2	88.5	98.1	90.8	84.5	90.5
	Average speed (m. p. h.)																
New York-Cleveland	90.4	87.8	89.3	89.6	96.6	89.6	88.4	90.0	89.6	88.6	86.1	89.7	91.8	89.3	88.1	89.3	89.6
Cleveland-Chicago	89.6	86.8	87.6	89.4	95.6	90.2	87.7	89.1	88.9	86.6	87.4	88.1	90.9	89.0	87.6	88.2	88.9
Chicago-Cleveland	107.1	106.5	105.0	104.5	94.9	93.3	96.6	95.5	98.7	104.5	106.2	105.7	101.5	95.1	103.1	106.4	101.5
Cleveland-New York	113.5	117.4	111.8	108.8	102.2	98.1	93.5	95.8	98.8	105.8	105.2	111.9	107.6	95.8	103.3	114.3	105.2

TABLE 2.—*Miscellaneous statistical data for flights between New York and Chicago, June, 1921, to May, 1923, inclusive*

	January	February	March	April	May	June	July	August	September	October	November	December	Spring	Summer	Autumn	Winter	Annual
Number of days, excluding Sundays and holidays	51	46	54	50	52	52	50	54	50	52	50	51	156	156	152	148	612
Number of flights each way	38	33	41	44	48	51	50	52	48	49	36	39	133	153	133	110	529
Percentage of possible	74.5	71.7	75.9	88.0	92.3	98.1	100.0	96.3	96.0	94.2	72.0	76.5	85.3	98.1	87.5	74.3	86.4
	New York–Chicago (m. p. h.)																
Average speed	89.0	88.0	90.0	89.6	96.4	89.8	88.0	89.4	89.2	87.8	87.0	88.6	92.0	89.1	88.0	88.5	89.4
Highest speed	122.2	117.6	113.4	125.6	113.4	104.1	106.1	106.2	108.1	119.0	109.7	110.8	125.6	106.2	119.0	122.2	125.6
Lowest speed	68.7	60.9	72.3	70.8	77.1	73.2	73.5	75.7	65.9	68.1	74.0	66.8	70.8	73.2	65.9	60.9	60.9
	Chicago–New York (m. p. h.)																
Average speed	110.4	112.8	108.0	106.8	98.8	96.0	94.8	95.6	98.8	105.4	105.4	110.6	104.5	95.5	103.2	111.1	103.6
Highest speed	139.7	154.0	137.5	130.5	129.4	120.5	111.3	112.4	128.3	145.0	136.3	145.8	137.5	120.5	145.0	154.0	154.0
Lowest speed	84.6	89.0	77.7	76.6	78.8	75.1	64.3	75.3	78.6	71.8	82.2	90.9	76.6	64.3	71.8	84.6	64.3
Normal cruising speed	99.7	100.4	99.0	98.2	97.6	92.9	91.4	92.5	94.0	96.6	96.2	99.6	98.2	92.3	95.6	99.8	96.5
Wind factor from data above given	10.7	12.4	9.0	8.6	1.2	3.1	3.4	3.1	4.8	8.8	9.2	11.0	6.2	3.2	7.6	11.3	7.1

TABLE 3.—*Miscellaneous statistical data for flights between New York and Chicago, June, 1922, to May, 1923, inclusive*

	January	February	March	April	May	June	July	August	September	October	November	December	Spring	Summer	Autumn	Winter	Annual
Number of days excluding Sundays and holidays	26	23	27	25	26	26	25	27	25	26	25	25	78	78	76	74	306
Number of flights each way	19	16	20	23	23	25	25	27	24	25	22	19	66	77	71	54	268
Percentage of possible	73.1	69.6	74.1	92.0	88.5	96.2	100.0	100.0	96.0	96.2	88.0	76.0	84.6	98.7	93.4	73.0	87.6
	New York–Chicago (m. p. h.)																
Average speed	89.1	89.6	89.6	91.7	99.4	91.1	91.8	93.2	92.9	91.4	88.1	90.3	93.6	92.0	90.8	89.7	91.5
Highest speed	122.2	117.6	113.4	125.6	113.4	100.3	106.1	106.2	108.1	109.8	109.7	110.8	125.6	106.2	109.8	122.2	125.6
Lowest speed	74.2	60.9	72.3	77.0	79.4	76.2	80.4	79.5	81.1	76.5	74.0	66.8	72.3	76.2	74.0	60.9	60.9
	Chicago–New York (m. p. h.)																
Average speed	113.7	117.7	116.1	109.4	99.7	99.9	98.7	97.1	98.1	106.8	110.3	115.8	108.4	98.6	105.1	115.7	106.9
Highest speed	139.7	154.0	137.5	129.6	129.4	120.5	110.3	112.4	112.1	145.0	136.3	145.8	137.5	120.5	145.0	154.0	154.0
Lowest speed	86.2	100.3	104.1	80.4	85.8	85.3	83.6	84.6	78.6	71.8	88.3	90.9	80.4	83.6	71.8	86.2	71.8
Normal cruising speed	101.4	103.6	102.8	100.6	99.6	95.5	95.2	95.2	95.5	99.1	99.2	103.0	101.0	95.3	98.0	102.7	99.2
Wind factor	12.3	14.0	13.2	8.8	0.2	4.4	3.4	2.0	2.6	7.7	11.1	12.8	7.4	3.3	7.2	13.0	7.7

TABLE 4.—*Number and percentage of flights made from New York to Chicago at or above different average speeds during the period June, 1921, to May, 1923, inclusive*

Speed (m. p. h.)	Time of flight	Number of flights: Spring	Summer	Autumn	Winter	Annual	Percentage of total number: Spring	Summer	Autumn	Winter	Annual
126	6.11	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
124	6.21	1	0	0	0	1	0.8	0.0	0.0	0.0	0.2
122	6.31	1	0	0	1	2	0.8	0.0	0.0	0.9	0.4
120	6.42	1	0	0	1	2	0.8	0.0	0.0	0.9	0.4
118	6.53	1	0	1	1	3	0.8	0.0	0.8	0.9	0.6
116	6.64	1	0	1	2	4	0.8	0.0	0.8	1.8	0.8
114	6.75	1	0	1	2	4	0.8	0.0	0.8	1.8	0.8
112	6.88	5	0	1	3	9	3.8	0.0	0.8	2.7	1.7
110	7.00	9	0	1	5	15	6.8	0.0	0.8	4.5	2.8
108	7.13	12	0	6	5	23	9.0	0.0	4.5	4.5	4.3
106	7.26	18	2	8	7	35	13.5	1.3	6.0	6.4	6.6
104	7.40	23	5	11	13	52	17.3	3.3	8.3	11.8	9.8
102	7.55	27	8	15	16	66	20.3	5.2	11.3	14.5	12.5
100	7.70	37	15	20	21	93	27.8	9.8	15.0	13.6	17.6
98	7.86	46	24	25	26	121	34.6	15.7	18.8	23.6	22.9
96	8.02	53	34	30	33	150	39.8	22.2	22.6	30.0	28.4
94	8.19	60	47	38	37	182	45.1	30.7	28.6	33.6	34.4
92	8.37	75	56	48	49	228	56.4	36.6	36.1	44.5	43.1
90	8.56	85	77	58	54	274	63.9	50.3	43.6	49.1	51.8
88	8.75	90	96	71	57	314	67.7	62.7	53.4	51.8	59.4
86	8.95	98	102	80	66	346	73.7	66.7	60.2	60.0	65.4
84	9.17	103	114	90	76	383	77.4	74.5	67.7	69.1	72.4
82	9.39	110	125	100	85	420	82.7	81.7	75.2	77.3	79.4
80	9.62	116	133	114	91	454	87.2	86.9	85.7	82.7	85.8
78	9.87	120	139	119	94	472	90.2	90.8	89.5	85.5	89.2
76	10.13	126	150	125	101	502	94.7	98.0	94.0	91.8	94.9
74	10.41	130	151	127	103	511	97.7	98.7	95.5	93.6	96.6
72	10.69	132	153	128	104	517	99.2	100.0	96.2	94.5	97.7
70	11.00	133	153	130	106	522	100.0	100.0	97.7	96.4	98.7
68	11.32	133	153	132	107	525	100.0	100.0	99.2	97.3	99.2
66	11.67	133	153	133	109	528	100.0	100.0	100.0	99.1	99.8
64	12.03	133	153	133	109	528	100.0	100.0	100.0	99.1	99.8
62	12.42	133	153	133	109	528	100.0	100.0	100.0	99.1	99.8
60	12.83	133	153	133	110	529	100.0	100.0	100.0	100.0	100.0

TABLE 5.—*Number and percentage of flights made from Chicago to New York at or above different average speeds during the period June, 1921, to May, 1923, inclusive*

Speed (m. p. h.)	Time of flight	Number of flights: Spring	Summer	Autumn	Winter	Annual	Percentage of total number: Spring	Summer	Autumn	Winter	Annual
156	4.93	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
154	5.00	0	0	0	1	1	0.0	0.0	0.0	0.9	0.2
152	5.07	0	0	0	1	1	0.0	0.0	0.0	0.9	0.2
150	5.13	0	0	0	1	1	0.0	0.0	0.0	0.9	0.2
148	5.20	0	0	0	1	1	0.0	0.0	0.0	0.9	0.2
146	5.27	0	0	0	1	1	0.0	0.0	0.0	0.9	0.2
144	5.35	0	0	1	2	3	0.0	0.0	0.8	1.8	0.6
142	5.42	0	0	1	2	3	0.0	0.0	0.8	1.8	0.6
140	5.50	0	0	1	2	3	0.0	0.0	0.8	1.8	0.6
138	5.58	0	0	1	4	5	0.0	0.0	0.8	3.6	0.9
136	5.66	1	0	3	6	10	0.8	0.0	2.3	5.5	1.9
134	5.75	1	0	4	7	12	0.8	0.0	3.0	6.4	2.3
132	5.83	2	0	4	8	14	1.5	0.0	3.0	7.3	2.6
130	5.92	4	0	4	8	16	3.0	0.0	3.0	7.3	3.0
128	6.02	8	0	7	10	25	6.0	0.0	5.3	9.1	4.7
126	6.11	9	0	9	15	33	6.8	0.0	6.8	13.6	6.2
124	6.21	13	0	10	20	43	9.8	0.0	7.5	18.2	8.1
122	6.31	20	0	14	23	57	15.0	0.0	10.5	20.9	10.8
120	6.42	24	1	16	31	72	18.0	0.7	12.0	28.2	13.6
118	6.53	25	1	20	38	84	18.8	0.7	15.0	34.5	15.9
116	6.64	30	1	27	44	102	22.6	0.7	20.3	40.0	19.3
114	6.75	36	2	33	52	123	27.1	1.3	24.8	47.3	23.3
112	6.88	42	3	41	57	143	31.6	2.0	30.8	51.8	27.0
110	7.00	47	10	44	63	164	35.3	6.5	33.1	57.3	31.0
108	7.13	51	15	58	67	191	38.3	9.8	43.6	60.9	36.1
106	7.26	59	26	63	74	222	44.4	17.0	47.4	67.3	42.0
104	7.40	71	37	67	79	254	53.4	24.1	50.4	71.8	48.0
102	7.55	84	52	71	88	295	63.2	34.0	53.4	80.0	55.8
100	7.70	91	65	81	93	330	68.4	42.5	60.9	84.5	62.4
98	7.86	93	77	88	352	94	69.9	50.3	66.2	85.5	66.5
96	8.02	99	80	97	95	371	74.4	52.3	72.9	86.4	70.0
94	8.19	106	90	104	97	397	79.7	58.8	78.2	88.2	75.1
92	8.37	111	100	109	101	421	83.5	65.4	82.0	91.8	79.6
90	8.56	114	112	117	106	449	85.7	73.2	88.0	96.4	84.9
88	8.75	121	124	122	108	475	91.0	81.0	91.7	98.2	89.8

TABLE 5.—*Number and percentage of flights made from Chicago to New York at or above different average speeds during the period June, 1921, to May, 1923, inclusive*—Continued

Speed (m. p. h.)	Time of flight	Number of flights: Spring	Summer	Autumn	Winter	Annual	Percentage of total number: Spring	Summer	Autumn	Winter	Annual
86	8.95	123	132	123	109	487	92.5	86.3	92.5	99.1	92.1
84	9.17	127	139	127	110	503	95.5	90.8	95.5	100.0	95.1
82	9.39	128	142	128	110	508	96.2	92.8	96.2	100.0	96.0
80	9.62	130	144	129	110	513	97.7	94.1	97.0	100.0	97.0
78	9.87	131	146	132	110	519	98.5	95.4	99.2	100.0	98.1
76	10.13	133	146	132	110	521	100.0	95.4	99.2	100.0	98.5
74	10.41	133	150	132	110	525	100.0	98.0	99.2	100.0	99.2
72	10.69	133	151	132	110	526	100.0	98.7	99.2	100.0	99.4
70	11.00	133	152	133	110	528	100.0	99.3	100.0	100.0	99.8
68	11.32	133	152	133	110	528	100.0	99.3	100.0	100.0	99.8
66	11.67	133	152	133	110	528	100.0	99.3	100.0	100.0	99.8
64	12.03	133	153	133	110	529	100.0	100.0	100.0	100.0	100.0

Tables 4 and 5 correspond to Tables 12 and 13 respectively of the former report and indicate the seasonal and annual number and percentage of flights made between New York and Chicago at or above the different average speeds. The annual percentages shown in the last column of Tables 4 and 5 are plotted in Figures 1 and 2, respectively. In figure 3 is given the resulting annual frequency of winds of different speeds, as derived from the preceding data. The winds determined from kite and pilot balloon records, as indicated in Figure 7 of the former paper, are also shown. Exactly the same

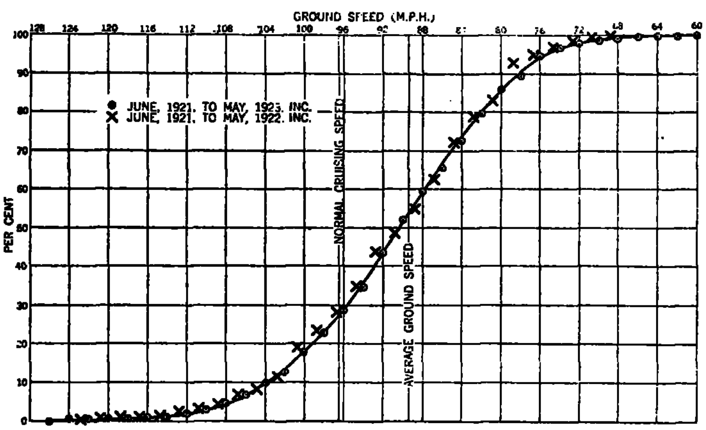

FIG. 1.—Percentage of trips made from New York to Chicago, 770 miles, at different average speeds with airplanes whose normal cruising speed is 96.5 miles per hour

assumption with regard to the increase in cruising speed of the planes is made as previously explained, viz, as opposing winds of increasing strength are encountered pilots advance the engine throttle until, against the extreme winds, a high speed is maintained approximately 15 per cent greater than the normal cruising speed shown in Table 2.

The data for the second fiscal year alone, June 1, 1922, to May 31, 1923, inclusive, are presented in Table 3 for comparison with the data of the former year and with the combined two-year record given in Table 2 above.

A comparison of the preceding data with those of the former report reveals several features of considerable interest:

THE WIND FACTOR

	M. p. h.
Air mail, fiscal year 1922	6.6
Air mail, fiscal year 1923	7.7
Air mail, two years combined	7.2
Kite and pilot-balloon data	7.4

These figures show that, as the period covered by the air mail records is extended, the wind factor determined therefrom approaches more and more closely the resultant wind computed from kite and pilot balloon observations. The wind factor adopted in the earlier paper was 7 m. p. h.; apparently, the correct value is nearer 7.3.

PERCENTAGE OF FLIGHTS AT DIFFERENT AVERAGE SPEEDS

As already stated, the values in the last columns of Tables 4 and 5 are plotted in Figures 1 and 2, respectively.

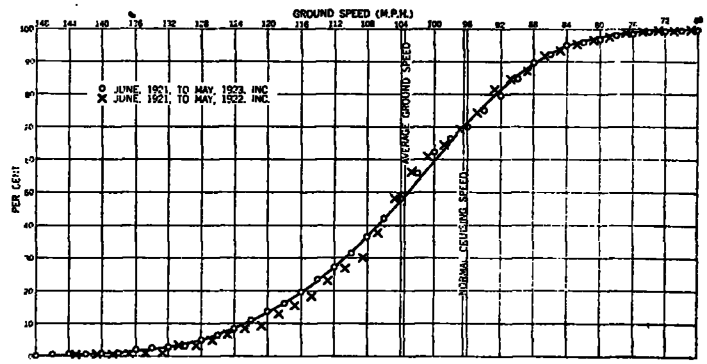

FIG. 2.—Percentage of trips made from Chicago to New York, 770 miles, at different average speeds with airplanes whose normal cruising speed is 96.5 miles per hour

When these are compared with Figures 2 and 3 in the earlier paper, a remarkable similarity is noted. If allowance is made for the slight increase in the normal cruising speed from 93.8 m. p. h. in the first year to 96.5 m. p. h. in the two years combined, the curves very nearly superimpose. In order to facilitate the comparison the values upon which the one-year curves are

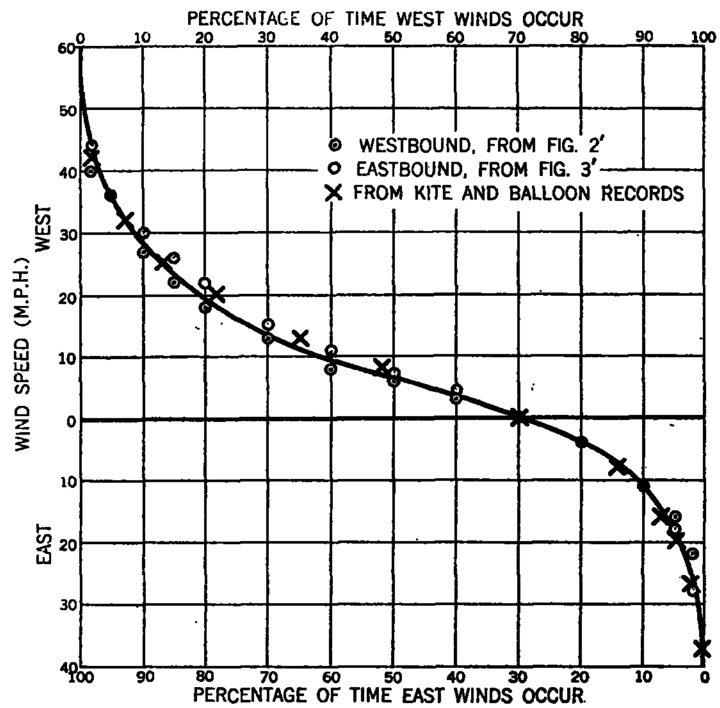

FIG. 3.—Annual percentage occurrence of east and west component winds of different speeds at 1,500 feet altitude along the New York-Chicago route

based have been indicated by crosses (×) on Figures 1 and 2. It is then seen that the effect of winds upon the ground speed of the planes (*a*) agrees almost exactly at the extremes in the two periods and (*b*) is increased 1 to 2 m. p. h. at the two "points of inflexion" and tends on the average to approach more closely the wind curve from kite and balloon data, as the period increases.

No material change is shown in the relative proportion of east and west component winds, viz, about 30 and 70 per cent, respectively.

The planes and motors used in the second year are of the same type as those used in the first. The slightly higher normal cruising speed can not therefore be attributed to aerodynamic causes. More likely it is an index of the increased efficiency resulting from the pilot's experience and familiarity with the motors and with the route. They lose less time wandering off the course; they have learned to take advantage of sheltered valleys, or now cross terrain about which they formerly used to detour; familiar with more emergency landing fields, they fly at a lower altitude against adverse winds; and with a better understanding of meteorological conditions, they take increasing advantage of favorable winds.[3]

FREQUENCY OF WINDS OF DIFFERENT SPEEDS

A comparison of Figure 3 with Figure 7 of the earlier paper shows:

(*a*) Very close agreement, especially with regard to the extreme winds;

(*b*) For the winds of moderate strength, the two-year average brings the curve 1 to 2 miles per hour nearer the values obtained by kite and pilot balloon observations:

(*c*) The relative proportion of east winds to west winds—namely, 30 per cent and 70 per cent—now agrees almost exactly for all three methods of determination;

(*d*) The strength of east or west winds which occur 5 per cent of the time is practically as found before: 36 m. p. h. from the west and 18 m. p. h. from the east; and

(*e*) The ordinate at the 50 per cent point is approximately 7 m. p. h. from the west, the wind factor again.

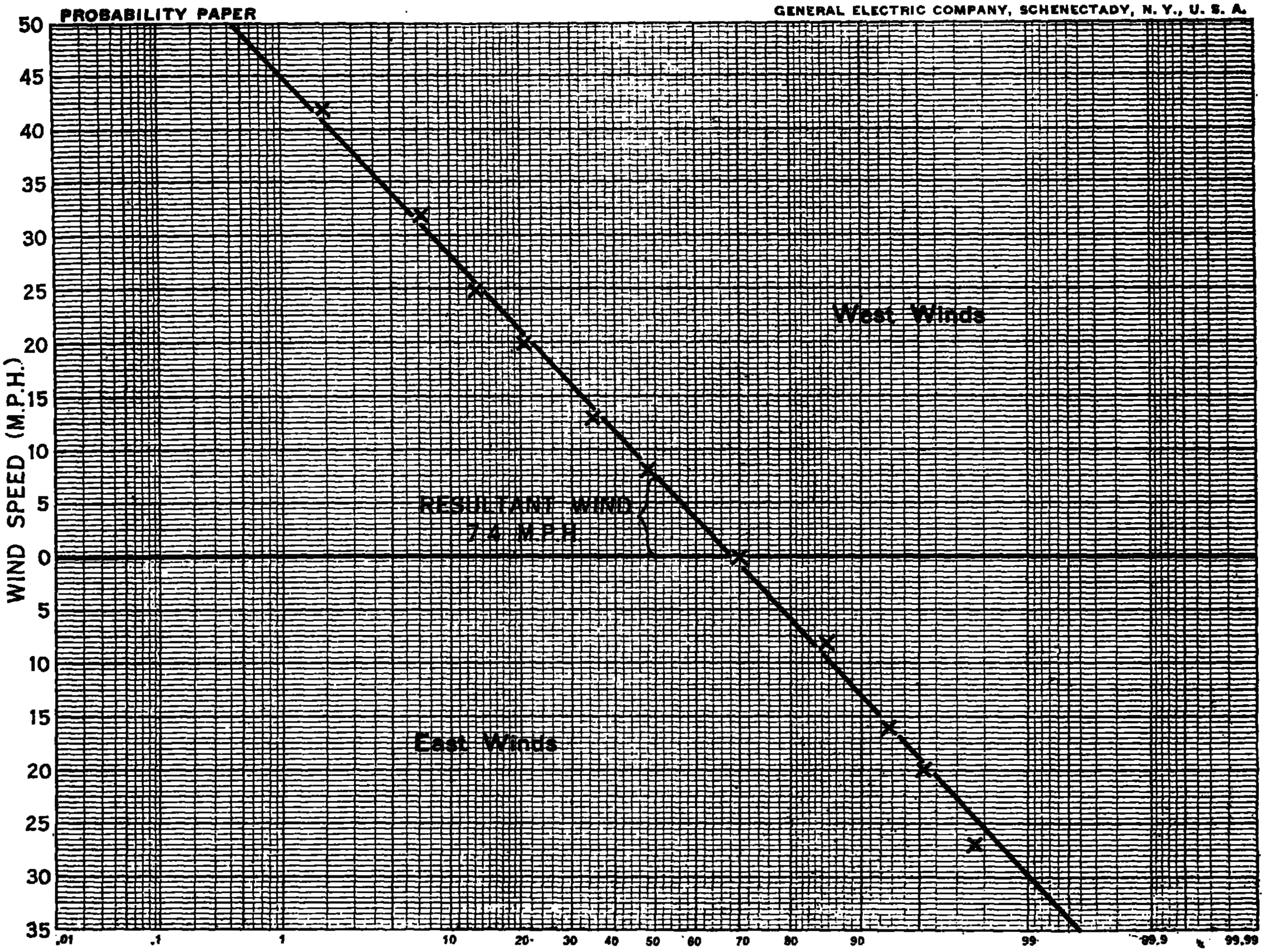

FIG. 4.—Annual percentage occurrence of east and west component winds of different speeds at 1,500 feet altitude along the New York-Chicago route, as determined from kite and pilot-balloon records

THE LAW OF PROBABILITY APPLIED TO THE FREQUENCY OF FREE-AIR WINDS OF DIFFERENT SPEEDS

It will be noted that the curve in Figure 3 is symmetrical about the point of intersection with the 50 per cent ordinate; that is, occurrence of winds with a velocity greater or less than the resultant wind becomes increasingly less frequent the further the strength of the winds departs from the mean value on either side. In other words, Figure 3 bears a striking resemblance to a "probability curve" and suggests that the frequency of occurrence of winds of different speeds may be expressed in terms of the well-known laws of probability.[4]

The general mathematical relation between a quantity v (in this case the velocity of the wind) and the proba-

[3] Of interest in this connection is the following statement from *The Aeroplane*, Feb. 20, 1924, p. 153, with reference to the Moscow-Konigsberg line: "On account of the better utilization of the favorable air currents, the average speed was increased this year in comparison with last year by 2.5 per cent; that is, from 137 km. (85 miles) to 141 km. (87 miles) per hour."

[4] The authors are indebted to Dr. A. R. Stevenson, jr., and Mr. C. Dantsizen, of the research department of the General Electric Co., for this interesting suggestion; also for calling attention to the use of "probability paper," discussed farther on in this paper.

bility, or frequency of its occurrence, P, is given by the equation:[5]

$$P = ke^{-h^2 v^2}$$

where h and k are constants.

If the law of probability does actually govern the distribution of the velocities of the different winds, the graph of Figure 3 must conform to the above general equation. A convenient method of determining this is by means of what is known as "arithmetic probability paper," whereon a probability curve, or curve of frequency, when plotted, will appear as a straight line.[6]

The frequency of east and west component winds of different speeds as found by kite and pilot-balloon records has therefore been replotted on probability paper and the result is shown in Figure 4. The points all lie remarkably closely along a straight line, the greatest deviation in observed frequency being 2.5 per cent, while the deviation in general is less than 1 per cent.

For this particular route, therefore, we have experimental evidence that the probability of occurrence of an east or west wind component of given speed may be predicted with surprising accuracy, by the law of probability, from the observed frequency of winds of other speeds. If this relationship between the velocity of a free-air wind and the probability of its occurrence can be shown to have general application for other routes as well, a powerful method is disclosed for the prediction of winds of different speeds when sufficient data are at hand to determine the trend of the probability curve. A preliminary examination of free-air wind data for other parts of the country indicates the correctness of this hypothesis.

In the present instance the winds, as determined from an increasing number of air mail flights, tend to approach more and more closely the winds as found by kite and pilot balloon observations. This is exactly what we should expect if the actual winds (as would be disclosed from an indefinite number of observations), really do vary in accordance with the law of probability.

SUMMARY AND CONCLUSIONS

1. An extension of the analysis of air mail records to cover two consecutive years of operation between New York and Chicago indicates that the winds as determined in the previous analysis from more limited data are substantially correct.

2. In general, the winds determined from an increasing number of flight records tend to conform more closely to the winds as found by kite and pilot balloon observations. The tendency is particularly evident in the determination of the wind factor.

3. A theoretical explanation of this improved agreement is suggested by the resemblance of the wind graph to a probability curve. The frequency of occurrence of winds of different speeds, as shown by aerological observations, is found to agree remarkably closely with the probability of such occurrence as predicted by the law of probabilities. This agreement suggests that the distribution of the velocities of free-air winds may be found in general to be governed by the probability law, in which case a powerful method is disclosed for predicting the frequency of a given wind speed when complete information is not at hand.

4. An interesting improvement in the general performance of the air mail planes is revealed by an increase of several miles per hour in the average cruising speed. This is indicative of the type of improvement which may be expected in an air transportation service as experience in operation is accumulated.

5. In view of the importance of an accurate knowledge of winds along routes where regular aircraft operations are likely to be initiated in the near future, the above results emphasize again the urgent need for a material extension of aerological investigations to cover all parts of the country.

[5] Merriman, Mansfield. Method of Least Squares. New York, 1915, p. 25

[6] For a discussion of the construction and use of this paper, see "Storage to be Provided in Impounding Reservoirs for Municipal Water Supply," by Allen Hazen. Trans. of Amer. Soc. of Civil Engineers, vol. 77, pp. 1539-1667, 1914; also, "The Element of Chance in Sanitation," by George C. Whipple. Journ. Franklin Inst., vol. 182, pp. 37-59, 205-227, 1916.

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RESULTS OF MEASUREMENTS OF SOLAR RADIATION AND ATMOSPHERIC TURBIDITY OVER THE ATLANTIC OCEAN AND IN ARGENTINA.—PRELIMINARY REPORT

By Dr. FRANZ LINKE

[Translated from manuscript text in German by W. W. Reed, Weather Bureau Washington, D. C., January 7, 1924]

1. *Data on the expedition.*—April 5, 1923, departure from Hamburg on the *General San Martin*; May 2, arrival at Buenos Aires; beginning of May to the beginning of July, journeys in Argentina; July 15, departure from Buenos Aires on the *Hindenburg*; August 15, arrival at Hamburg.

2. *Instruments.*—Universal actinometer of Hartmann & Braun of Frankfort on the Main, made according to special plans with a red-glass filter having a thickness of 3.02 mm. (Schott F. 4512) and range of transmissibility from 600 to 2,000 $\mu\mu$. Incandescent-lamp photometer with sodium cell of Günther & Tegetmeyer, Brunswick, with Wulf's bifilar electrometer and condensers of Siemens & Halske having capacity of 2, 0.5, and 0.1 microfarads. Blue scale for the estimation of sky color (mixture of white and Prussian blue) issued by the Unesma, Leipzig. Portable aspiration psychrometer of R. Fuess, Steglitz.

Previous to the departure from Hamburg, frequently in Argentina, and after the return from the expedition the actinometer was compared with an Ångström compensation pyrheliometer that had been adjusted to the revised (1913) Smithsonian scale by W. Marten at Potsdam. Unfortunately the condensers, which are necessary for incandescent-lamp radiation measurements with electrometers (galvanometers of requisite sensitiveness are not practicable on expeditions), gradually lose their state of insulation in the Tropics, so that great difficult is met with in the work.

3. *Methods of observation.*—Measurements were made only when the sun was unquestionably free of cloud and at every favorable time of the day. These were carried out more frequently in the mornings and evenings; during the midday hours long interruptions occurred. The apparatus for measuring radiation was exposed on shipboard on the roof of the pilot house on a table having Cardan's method of suspension (swinging table). All observations were made by me. At each reading the altitude of the sun was determined with the sextant. Observations of air pressure, temperature, and relative humidity were made several times daily. On the outward and on the return voyage when the sun was at its zenith position measurement was made of sky brightness for the spectrum range of the sodium cell (maximum sensitiveness about 360 $\mu\mu$.

The blue scale contained 8 color tones from white to ultramarine blue, and estimation was made to halves of the scale. No. 3 was white; No. 10, ultramarine blue.